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[54] **GRAPH DISPLAYING DEVICES AND METHODS**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **G09G 5/02**

[52] **U.S. Cl.** ..... **345/150**; 345/134; 345/133; 324/121 R

[58] **Field of Search** ..... 345/150, 440, 345/133, 134; 364/710.01; 324/121 R

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Primary Examiner—Richard A. Hjerpe

Assistant Examiner—Francis N. Nguyen

Attorney, Agent, or Firm—Frishauf, Holtz, Goodman, Langer & Chick

[57] **ABSTRACT**

A graph displaying device and method whereby when functional expression data for producing graphs and the conditions of displaying the graphs are set, graphs for functional expressions data input in accordance with the conditions are displayed in corresponding colors on a display. First, functional expression data and corresponding color data which designate display colors of the graphs are input in corresponding relationship. In addition, range data which display coordinates and color data designating display colors of coordinates involved in the range data are input together. In response to this operation, the graphs for the input functional expression data are produced with the range data to which the color data are designated, the last-mentioned color data corresponding to color data which correspond to the functional expression data. The produced graphs and the coordinates are displayed in the corresponding designated colors.

8 Claims, 9 Drawing Sheets

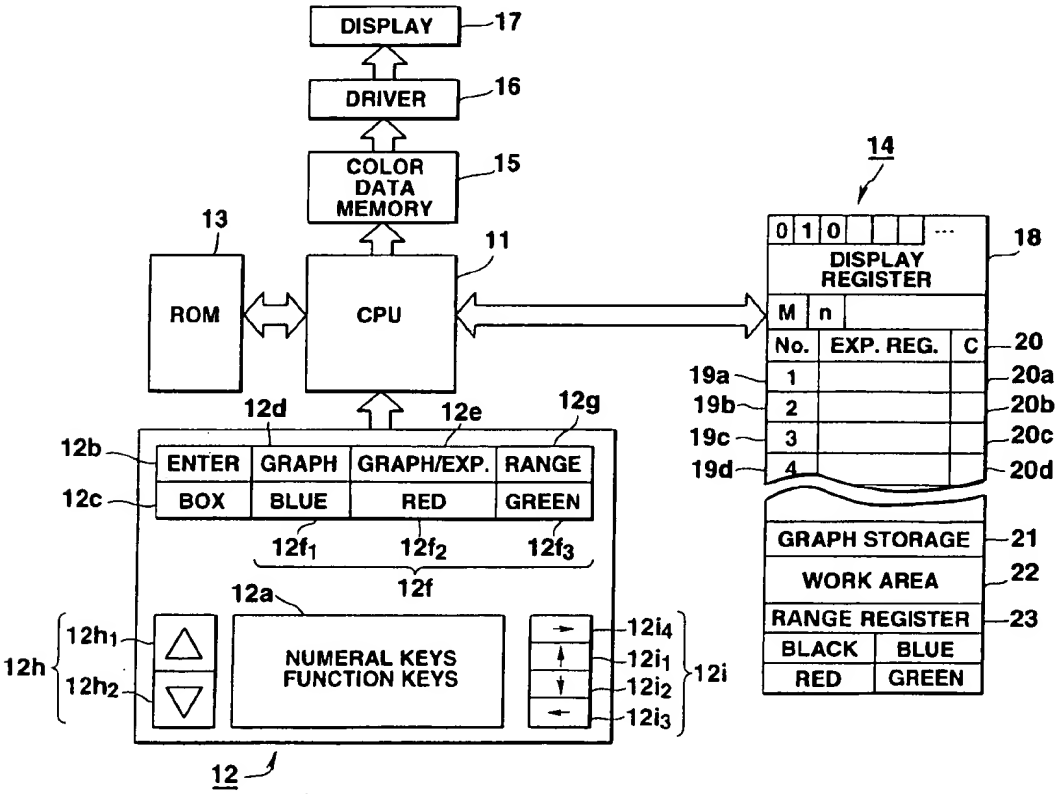


FIG.1

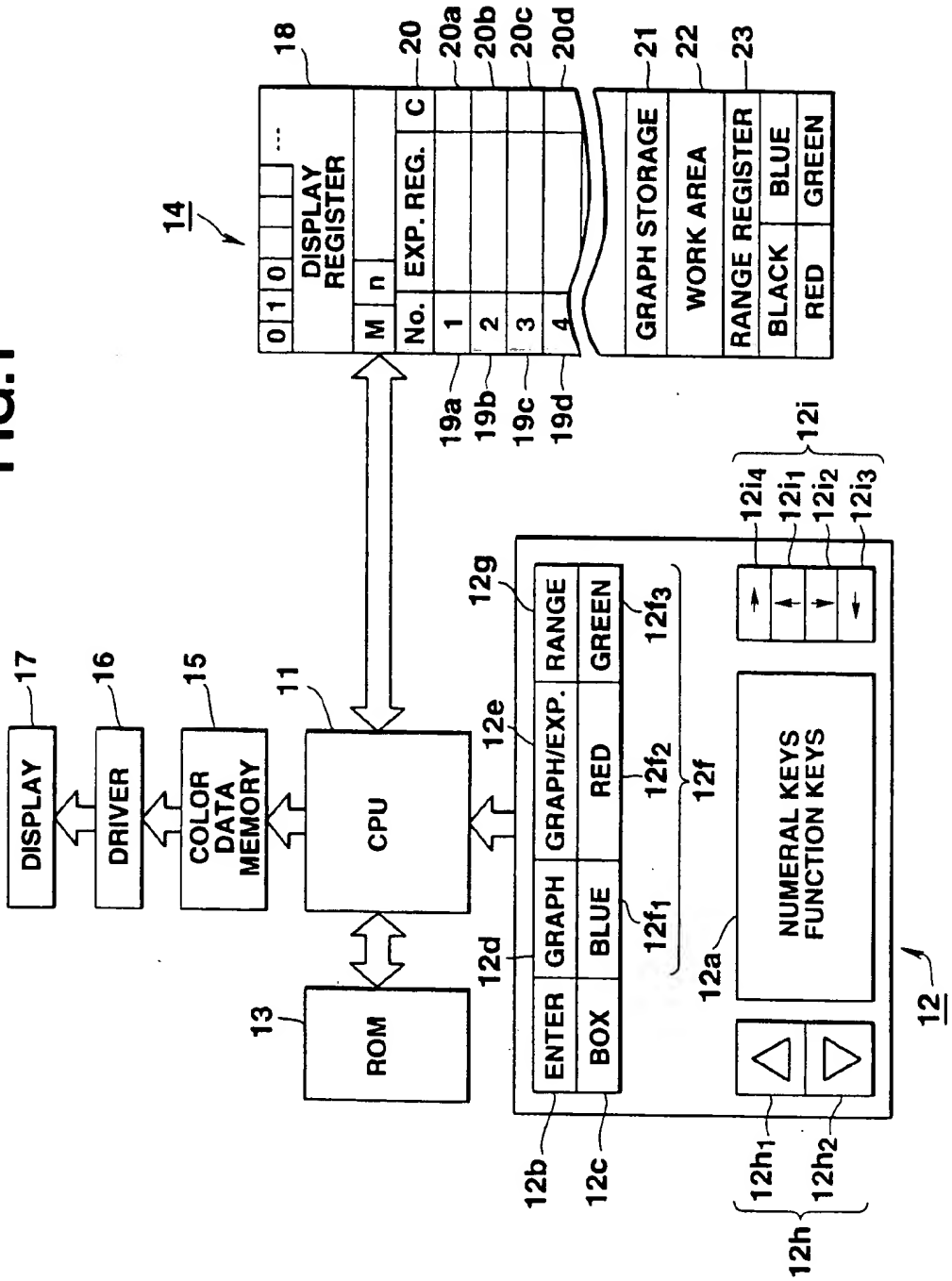

14
18
DISPLAY REGISTER
0 1 0 ...
M n
No.
EXP. REG.
C
20
20a
20b
20c
20d
1
2
3
4
19a
19b
19c
19d
21
22
23
GRAPH STORAGE
WORK AREA
RANGE REGISTER
BLACK
BLUE
RED
GREEN
12i
12i4
12i1
12i2
12i3
12g
RANGE
GREEN
12f3
12e
GRAPH/EXP.
RED
12f2
12f
12d
GRAPH
BLUE
12f1
ENTER
BOX
12b
12c
12a
NUMERAL KEYS
FUNCTION KEYS
12h1
12h2
12h
12
17
16
15
11
13
DISPLAY
DRIVER
COLOR DATA MEMORY
CPU
ROM

FIG.2

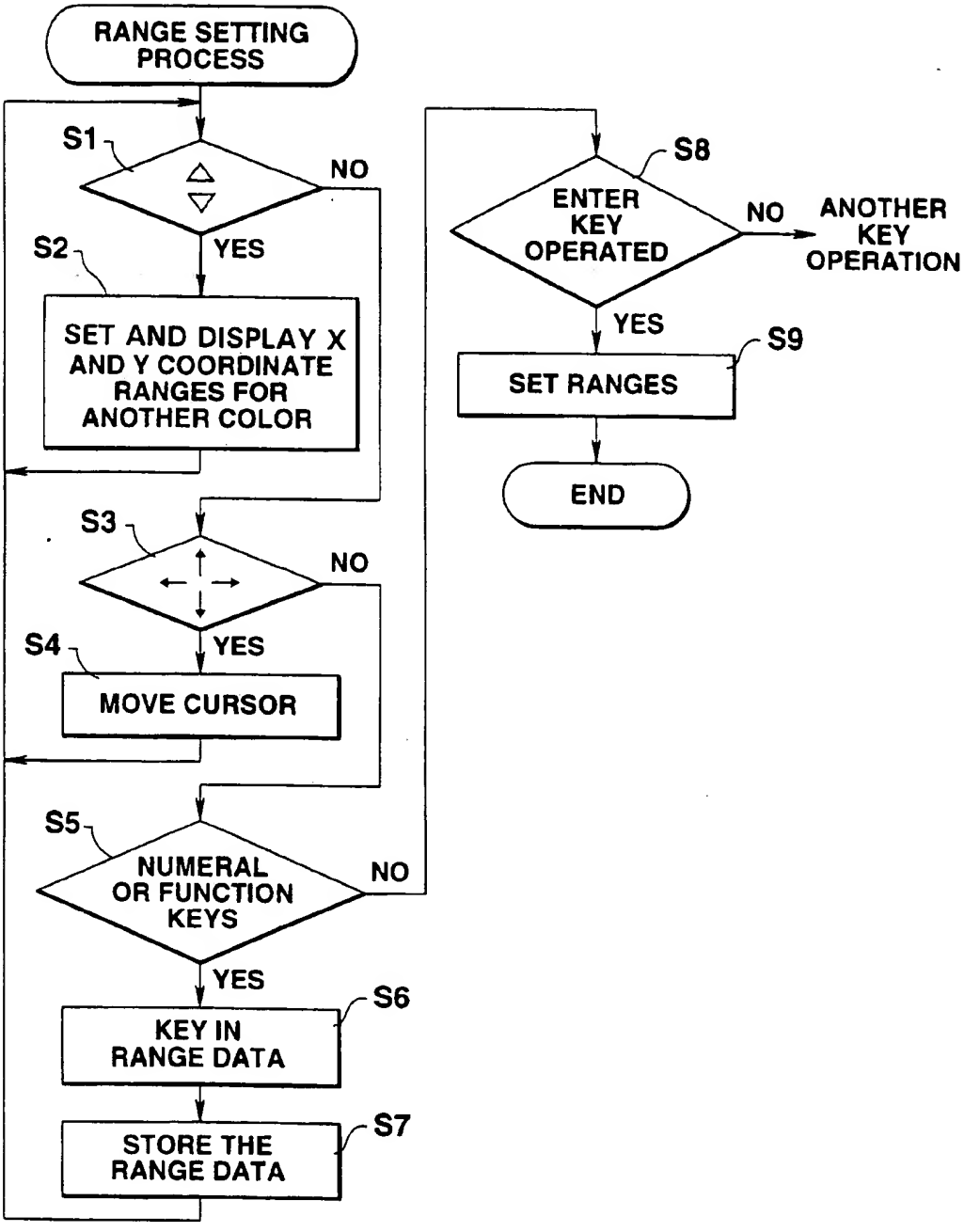

RANGE SETTING PROCESS
S1
NO
YES
S2
SET AND DISPLAY X AND Y COORDINATE RANGES FOR ANOTHER COLOR
S3
NO
YES
S4
MOVE CURSOR
S5
NUMERAL OR FUNCTION KEYS
NO
YES
S6
KEY IN RANGE DATA
S7
STORE THE RANGE DATA
S8
ENTER KEY OPERATED
NO
ANOTHER KEY OPERATION
YES
S9
SET RANGES
END

FIG.3

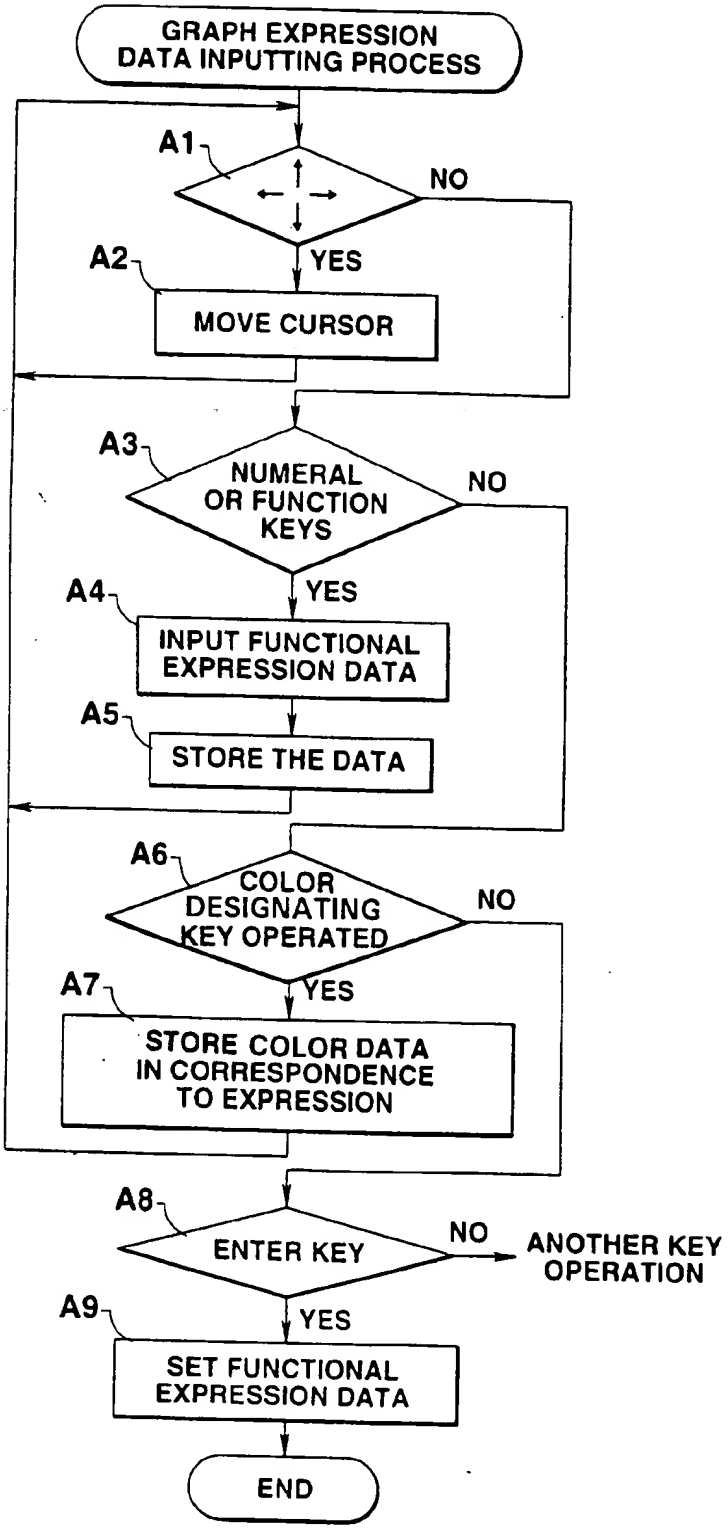

GRAPH EXPRESSION DATA INPUTTING PROCESS
A1
NO
YES
A2
MOVE CURSOR
A3
NUMERAL OR FUNCTION KEYS
NO
YES
A4
INPUT FUNCTIONAL EXPRESSION DATA
A5
STORE THE DATA
A6
COLOR DESIGNATING KEY OPERATED
NO
YES
A7
STORE COLOR DATA IN CORRESPONDENCE TO EXPRESSION
A8
ENTER KEY
NO
ANOTHER KEY OPERATION
YES
A9
SET FUNCTIONAL EXPRESSION DATA
END

FIG.4

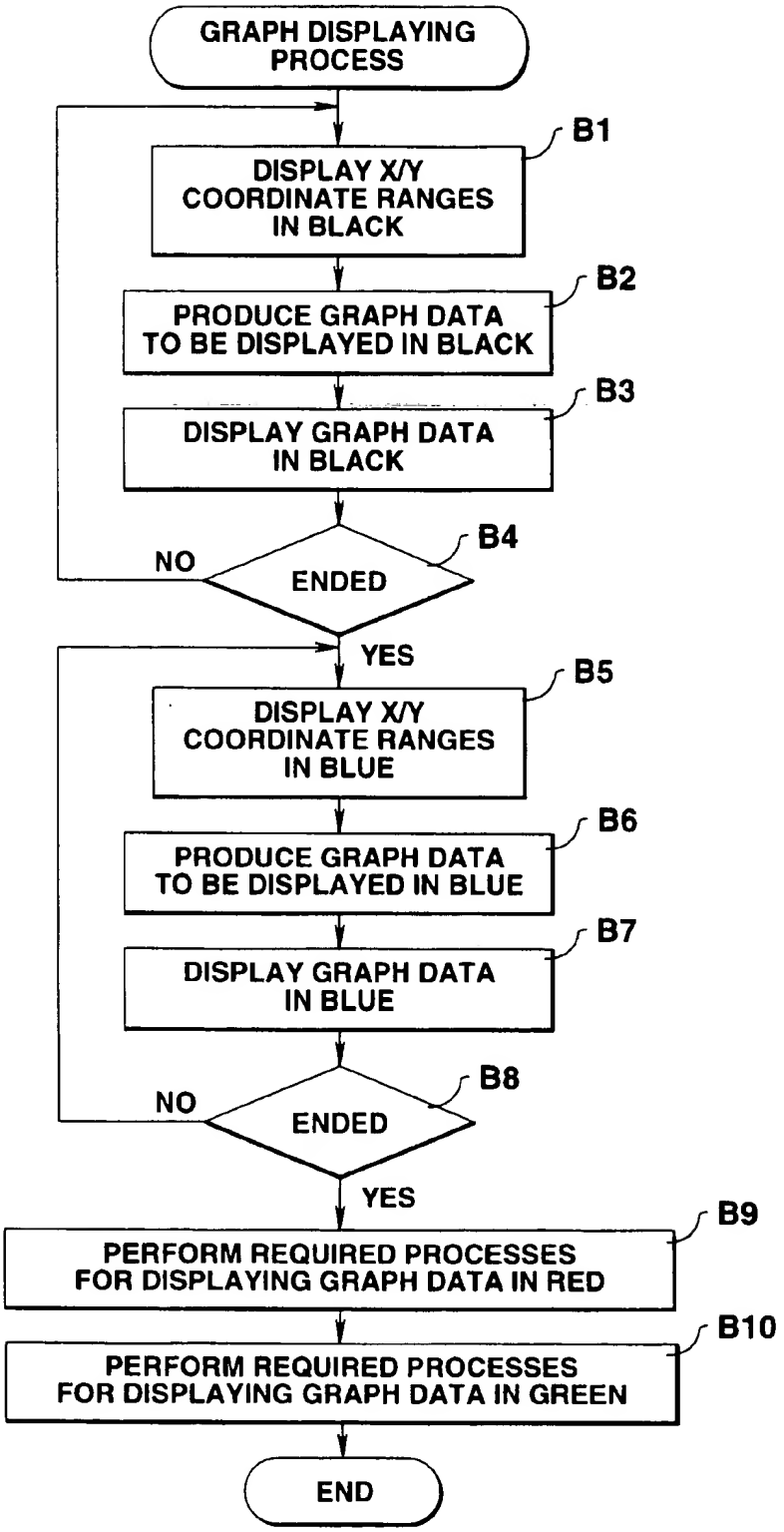

GRAPH DISPLAYING PROCESS
B1
DISPLAY X/Y COORDINATE RANGES IN BLACK
B2
PRODUCE GRAPH DATA TO BE DISPLAYED IN BLACK
B3
DISPLAY GRAPH DATA IN BLACK
B4
ENDED
NO
YES
B5
DISPLAY X/Y COORDINATE RANGES IN BLUE
B6
PRODUCE GRAPH DATA TO BE DISPLAYED IN BLUE
B7
DISPLAY GRAPH DATA IN BLUE
B8
ENDED
NO
YES
B9
PERFORM REQUIRED PROCESSES FOR DISPLAYING GRAPH DATA IN RED
B10
PERFORM REQUIRED PROCESSES FOR DISPLAYING GRAPH DATA IN GREEN
END

FIG.5A

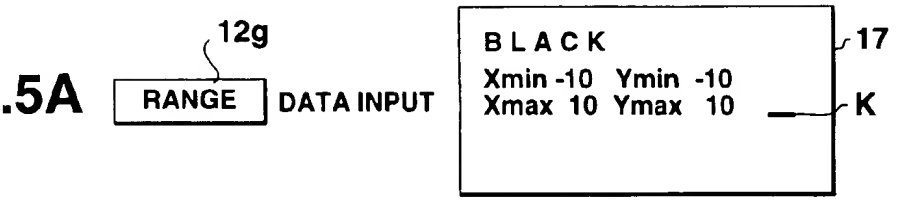


FIG.5B

FIG.5C

FIG.5D

FIG.5E

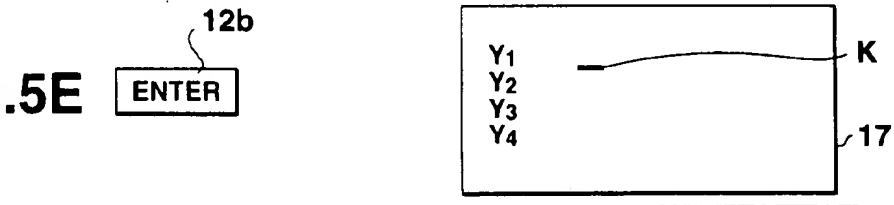


FIG.5F

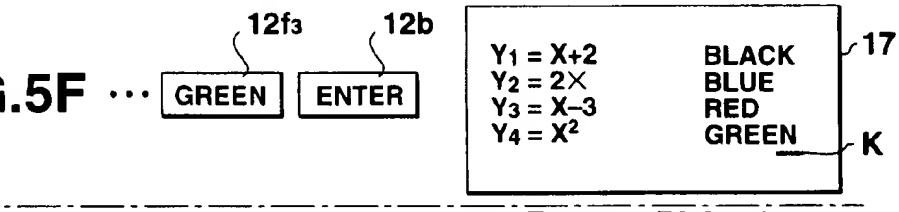


FIG.5G

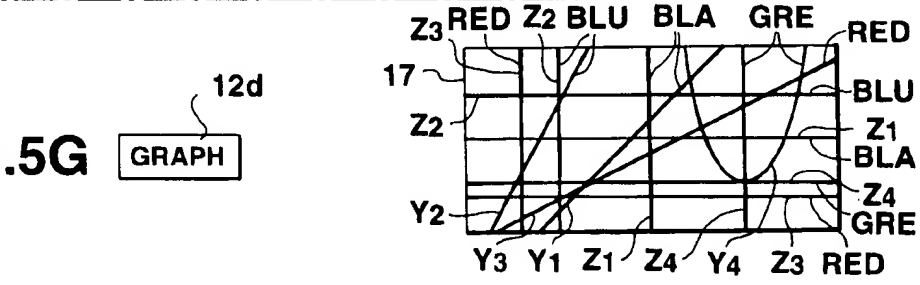
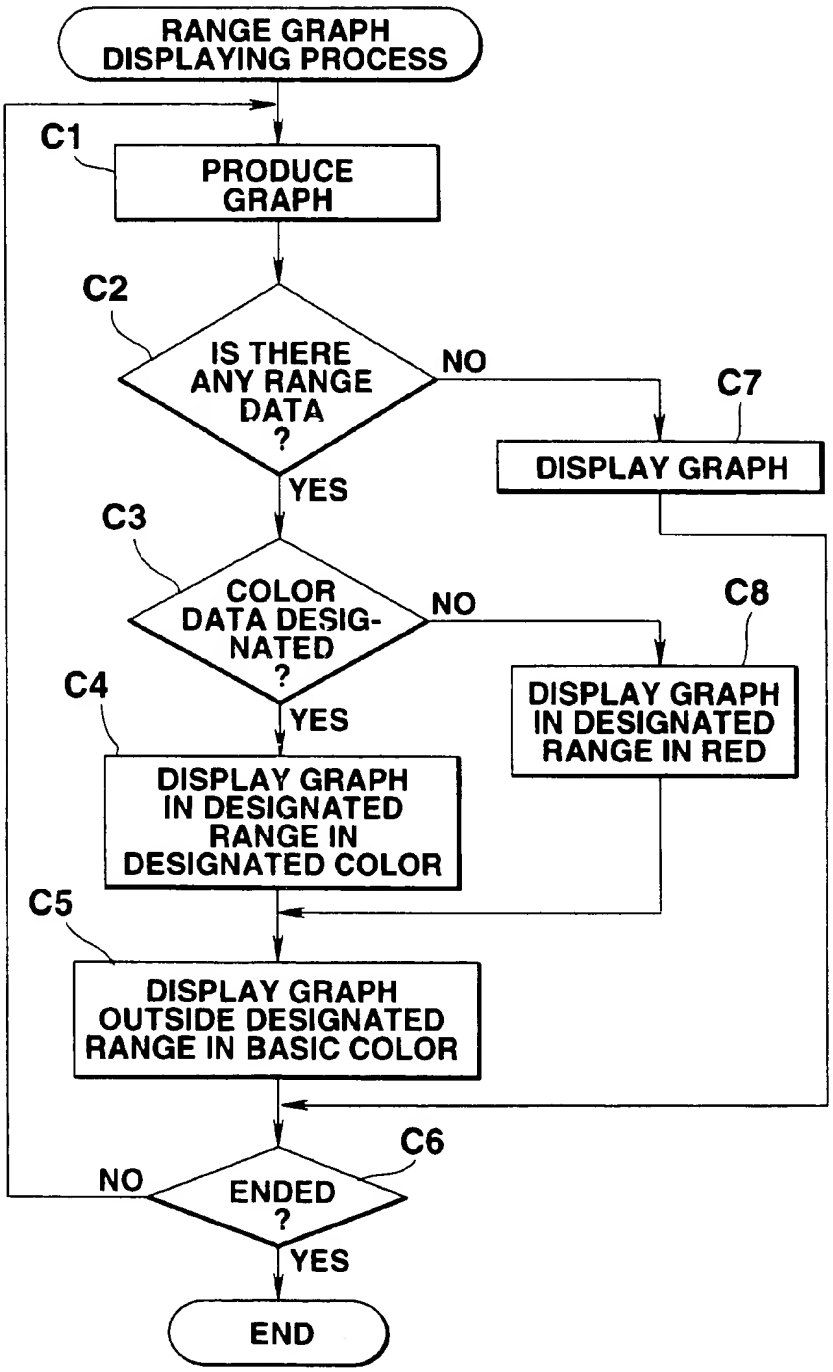


FIG.6


RANGE GRAPH DISPLAYING PROCESS
C1
PRODUCE GRAPH
C2
IS THERE ANY RANGE DATA ?
NO
C7
DISPLAY GRAPH
YES
C3
COLOR DATA DESIG-NATED ?
NO
C8
DISPLAY GRAPH IN DESIGNATED RANGE IN RED
YES
C4
DISPLAY GRAPH IN DESIGNATED RANGE IN DESIGNATED COLOR
C5
DISPLAY GRAPH OUTSIDE DESIGNATED RANGE IN BASIC COLOR
C6
NO
ENDED ?
YES
END

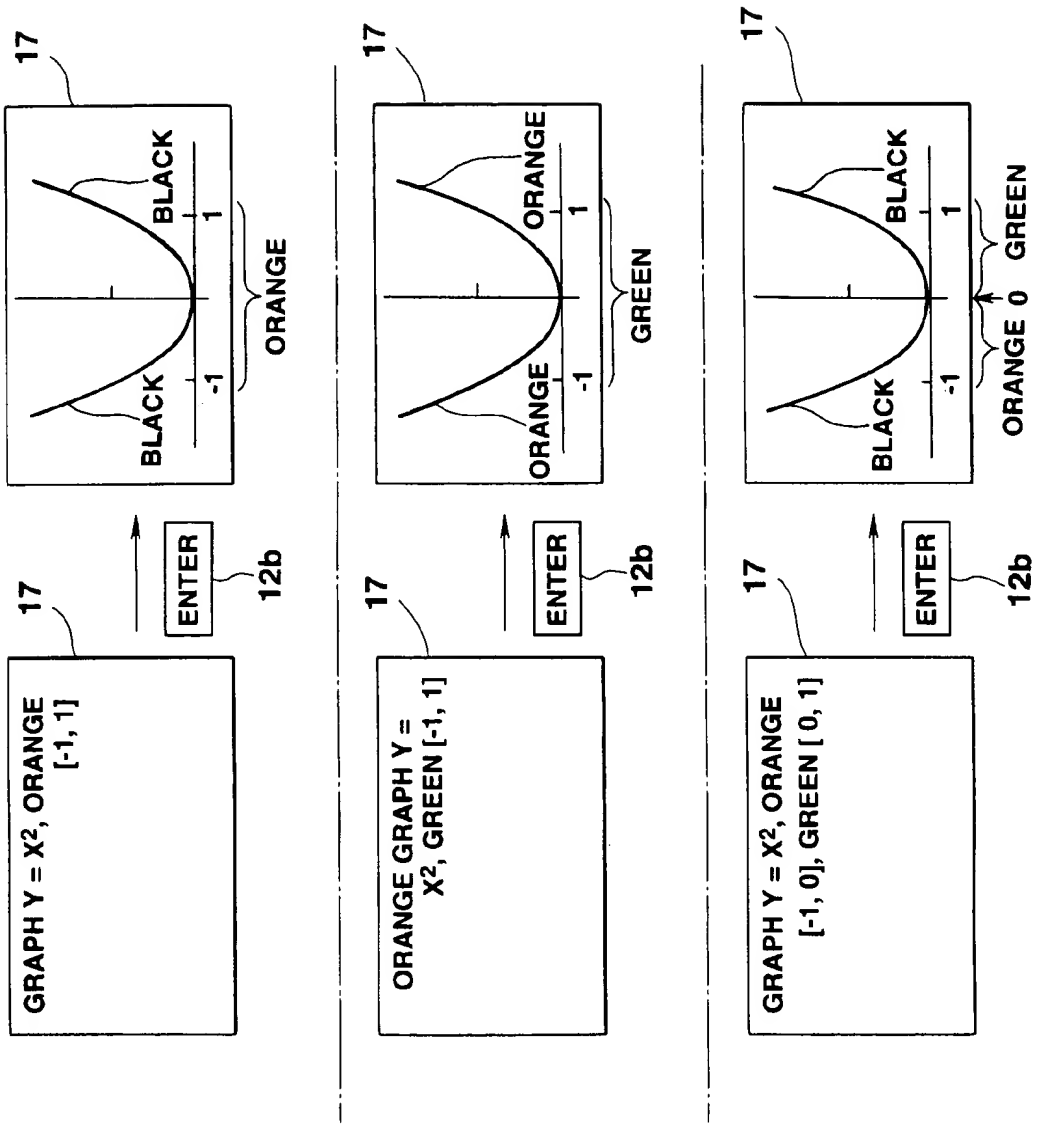
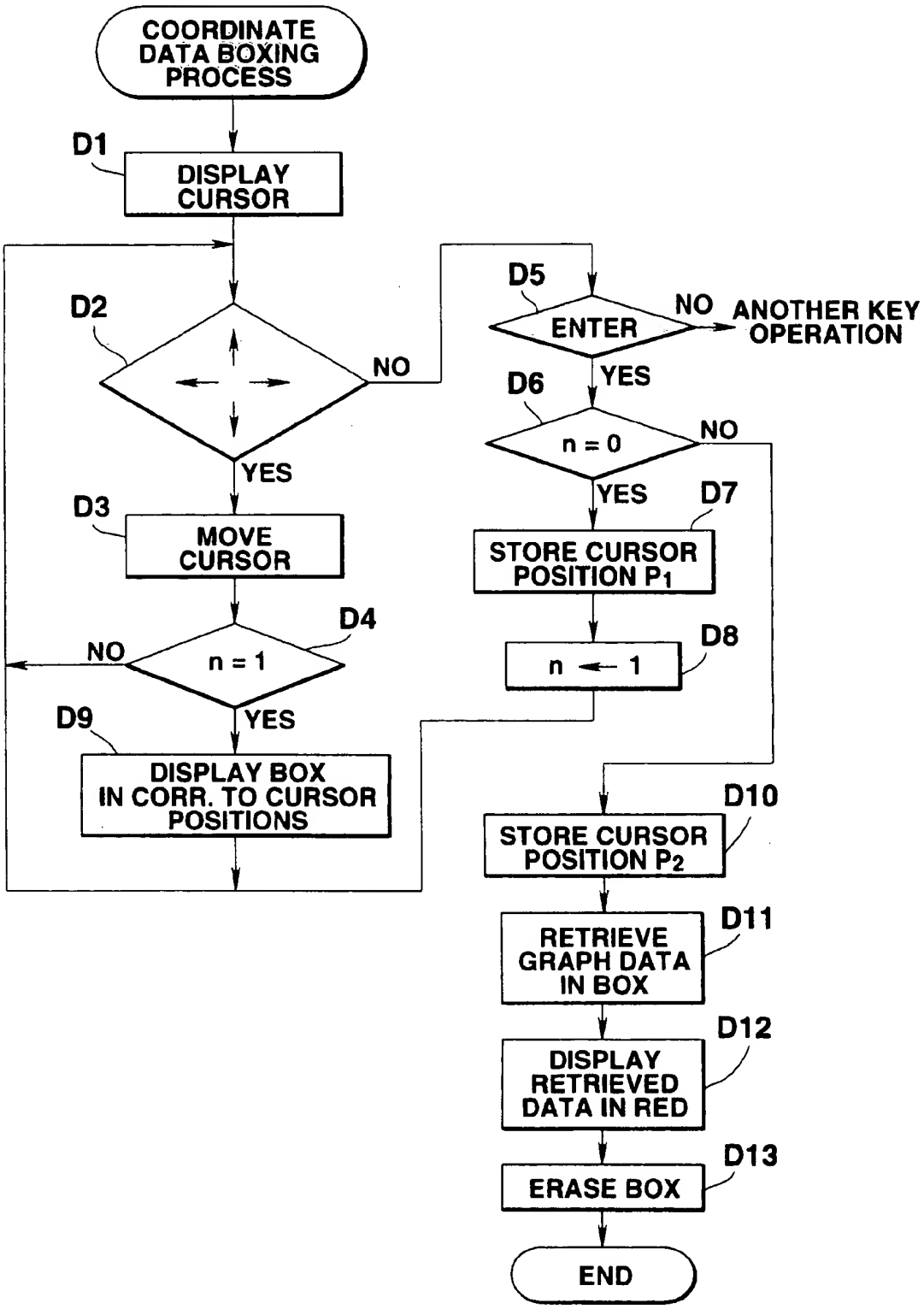


FIG.7A

FIG.7B

FIG.7C

FIG.8


COORDINATE DATA BOXING PROCESS
D1
DISPLAY CURSOR
D2
NO
YES
D3
MOVE CURSOR
D4
n = 1
NO
YES
D9
DISPLAY BOX IN CORR. TO CURSOR POSITIONS
D5
ENTER
NO
ANOTHER KEY OPERATION
YES
D6
n = 0
NO
YES
D7
STORE CURSOR POSITION P1
D8
n ← 1
D10
STORE CURSOR POSITION P2
D11
RETRIEVE GRAPH DATA IN BOX
D12
DISPLAY RETRIEVED DATA IN RED
D13
ERASE BOX
END

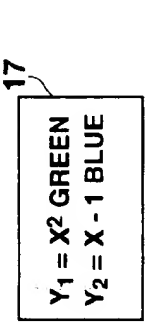


FIG.9A

FIG.9B

FIG.9C

FIG.9D

FIG.9E

GRAPH DISPLAYING DEVICES AND METHODS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to graph displaying devices and methods which input functional expression data to display same as a graph and more particularly to a graph display device and method which displays input functional expression data graph in color on a color display device.

2. Description of the Related Art

Conventionally, a graph display device, for example, for an electronic graphic calculator which displays input functional expression data as a graph, has been put to practical use.

In the graph display device of this type, when functional data, for example for Y=f(X), is input, numerical values obtained depending on range data set in a range of display on the display device are input to the functional expression and operated to produce graph delineating data which is then displayed as a graph. In this case, with a conventional graph display device and, more particularly, with an electronic graphic calculator, the input functional expression data and its graph data are displayed in black on a white screen of a liquid crystal display device.

When, for example, an X-coordinate range is set to display a graph for functional expression data, only graph data in the set range is displayed as a graph irrespective of the maximum coordinate range displayable in the whole display area of the liquid crystal display.

When only graph data in a set range of coordinates is displayed as a graph as in the conventional graph display device, however, the whole shape of the graph is difficult to understand. Thus, it is necessary to additionally display graph data outside the set range in some form separately from the graph data in the set range.

Graph data for the input functional expression data is conventionally all displayed usually in the same color, so that when, for example, plural-functional expression data is input and the corresponding individual-graph data are together displayed, the individual-graph data are very difficult to discriminate from each other.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a graph display device and method which is capable of optionally separating and clearly displaying a part of graph data corresponding to functional expression data, and displaying together individualgraph data corresponding to plural functional expression data in a very plain manner.

In order to achieve the above object, according to the present invention, there is provided a graph display device, comprising:

expression inputting means for inputting functional expression data and color data in corresponding relationship;

functional expression data storing means for storing the input functional expression data and the color data in corresponding relationship;

coordinate range data inputting means for inputting coordinate range data for setting a coordinate range and color data in corresponding relationship;

coordinate range data storing means for storing the coordinate range data and color data input by the coordinate range data inputting means in corresponding relationship; and

graph producing means for producing a graph for the functional expression data stored in the functional expression data storing means in the coordinate range involved in the coordinate range data and the plural color data stored in corresponding relationship in the coordinate range data storing means, the color data stored in corresponding relationship to the coordinate range data in the coordinate range storing means being the same as the color data stored in corresponding relationship to the functional expression data in the functional expression data storing means.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an electronic circuit of a computer having a graph displaying function as an embodiment of a graph displaying device according to the present invention;

FIG. **2** is a flow chart indicative of the whole coordinate range setting process performed by the computer;

FIG. **3** is a flow chart indicative of a graph expression data inputting process performed in the computer;

FIG. **4** is a flow chart indicative of a graph displaying process performed by the computer;

FIGS. **5A–5G** show display operations corresponding to key operations involved in the whole coordinate range setting process, graph expression data inputting process and graph displaying process performed by the computer;

FIG. **6** is a flow chart indicative of a range graph displaying process performed by the computer;

FIGS. **7A**, B and C each show a display operation corresponding to an expression data inputting operation involved in the range graph displaying process performed by the computer;

FIG. **8** is a flow chart indicative of a coordinate data boxing process performed by the computer;

FIGS. **9A–9E** each shows display operations corresponding to key operations involved in the coordinate data boxing process performed by the computer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of a graph displaying device and method according to the present invention will now be described in detail with reference to the accompanying drawings.

FIG. **1** is a block diagram of an electronic circuit of a computer having a graph displaying function as an embodiment of a graph displaying device according to the present invention.

The computer includes a CPU **11**, which starts up a system program contained in a ROM **13** in accordance with a key-in signal from a key-in unit **12** to control the respective operations of the circuit elements concerned. The CPU **11** is connected to the key-in unit **12** and ROM **13** as well as to a RAM **14**, a color data memory **15** and via a display driver **16** to a color liquid crystal display **17**.

The key-in unit **12** includes numeral keys and functional keys **12***a*, "ENTER" key **12***b*, "BOX" key **12***c*, "GRAPH" key **12***d*, "GRAPH/EXPRESSION" key **12***e*, color designating keys **12***f* ("BLUE" key $12f_1$, "RED" key $12f_2$, "GREEN" key $12f_3$), "RANGE" key **12***g*, range data selection keys **12***h* ("Δ" key $12h_1$, "▽" key $12h_2$), and cursor keys **12***i* ("↑" key $12i_1$, "↓" key $12i_2$, "←" key **12** i_3, "→" key $12i_4$).

The numeral and function keys **12***a* are operated to input data on desired expressions such as operation expressions

and functional expressions, and numerical data. The "ENTER" key **12***b* is operated to command the execution of the respective functions.

The "BOX" key **12***c* is operated to set a box mode to discriminate a desired display range on a graph display screen by enclosing that range in a square (box).

The "GRAPH" key **12***d* is operated to calculate and display graph data corresponding to functional expression data input by operating the numeral keys and function keys **12***a*.

The "GRAPH/EXPRESSION" key **12***e* is operated to switch between the display state of the input functional expression data and the display state of graph data.

The color designating keys **12***f* ("BLUE" key $12f_1$, "RED" $12f_2$, "GREEN" key $12f_3$) are each operated to designate a graph display color for the input functional expression data.

The "RANGE" key **12***g* is operated to set respective X and Y coordinate ranges when their graph display is performed.

The range selection keys **12***h* ("Δ" key $12h_1$, "∇" key $12h_2$) are operated to select four respective kinds of coordinate ranges separated, for example, in four different colors ("BLACK", "BLUE", "RED" and "GREEN") when the coordinate ranges involved in the operation of the "RANGE" key **12***g* are set.

The cursor keys **12***i* ("↑" key $12i_1$, "↓" key $12i_2$, "←" key $12i_3$, "→" key $12i_4$) are operated to move the cursor on the display screen.

The ROM **13** contains a system program in charge of control over the whole operation of the computer, and subprograms in charge of control of operations in the calculation mode, graph display range setting mode, graph expression data inputting mode, graph displaying mode, range graph displaying mode and boxing mode.

The RAM **14** includes a display register **18**, mode flag register M, cursor setting flag register n, expression registers **19** (**19***a*, **19***b*, **19***c*, **19***d*, . . .) designated color-registers **C20** (**20***a*, **20***b*, **20***c*, **20***d*, . . .) graph storage area **21**, work area **22** and range register **23**.

The display register **18** has data storage locations corresponding in one-to-one relationship to display dots in the display area of the display **17** and stores bit map data composed of display data "1" which implies being lighted corresponding to black display and "0" which implies being unlighted corresponding to white display.

The mode flag register M sets therein flag data corresponding to the respective operation modes. The cursor setting flag register N sets therein "1" when a first cursor movement position is determined in the formation of a box in the boxing process.

The expression registers **19** (**19***a*, **19***b*, **19***c*, **19***d*, . . .) store input plural expression data. The designated color registers **C20** (**20***a*, **20***b*, **20***c*, **20***d*, . . .) store displayed designated colors of the stored input expression data as "1", "2", "3", "4", . . . for black, blue, red, green, . . . respectively.

The graph storage area **21** stores respective graph data for the input expression data stored in the expression registers **19** (**19***a*, **19***b*, **19***c*, **19***d*, . . .) as respective bit map data corresponding to their display patterns.

The work area **22** temporarily stores various data input/output involved in various controlling processes performed by the CPU **11**.

The range register **23** stores data on the four kinds of coordinate ranges obtained by setting the respective ranges of X and Y coordinates in the graph display in correspondence to four different designated colors "BLACK", "BLUE", "RED" and "GREEN".

The color data memory **15** includes four ("BLACK", "BLUE", "RED", "GREEN") data storage areas, each corresponding in one-to-one dot relationship to the display area of the display **17** similar to the display register **18** provided in the RAM **14**. For example, when respective dot portions of display data to be stored in the display register **18** of RAM **14** are designated as black and blue, the respective designated dot portions are transferred directly to the corresponding black and blue display areas, respectively, of the color data memory **15** and then displayed via display driver **16** on the display **17**. When the input expression data is stored, first, "1" indicative of black display is initially set in the designated color register **C20** corresponding to the expression register **19** of the RAM **14**.

The graph display of the inventive computer will be described next.

FIG. **2** is a flow chart indicative of the whole coordinate range setting process performed by the computer.

FIG. **3** is a flow chart indicative of a graph expression data inputting process performed in the computer.

FIG. **4** is a flow chart indicative of a graph displaying process performed by the computer.

FIGS. **5A–5G** show display operations corresponding to key operations involved in the whole coordinate range setting process, graph expression data inputting process and graph display process performed by the computer.

When the "RANGE" key **12***g* of the key-in unit **12** is operated, as shown in FIG. **5A**, to set a coordinate range corresponding to the whole screen for the graph display in the whole coordinate range setting process of FIG. **2**, a black range setting screen "BLACK/Xmin?, Xmax?/Ymin?, Ymax?" which urges the user to set the X and Y coordinate ranges corresponding to the black coordinates "BLACK" is initially displayed on the display **17**.

When the numeral keys and function keys **12***a* are operated to input numerical data, the numerical data is displayed in the coordinate range corresponding to the position indicated by the cursor k and stored in the range register **23** of RAM **14**, for example, as "BLACK/Xmin −10"(step **S5**→**S6**, **S7**).

When cursor keys **12***i* ("↑" key $12i_1$, "↓" key $12i_2$, "←" key $12i_3$, "→" key $12i_4$) are operated, the cursor k is moved correspondingly to a position where another range is set on the black range setting screen "BLACK/Xmin −10, Xmax?/Ymin?, Ymax?"(step **S3**→**S4**).

When the numerical and function keys **12***a* are then operated again to input, for example, "BLACK/Xmax 10", this data is stored in the range register **23** of RAM **14** (step **S5**→**S6**, **S7**).

In this way, the respective range setting processes and cursor moving process at steps **S3–S7** are repeated such that the X and Y coordinate ranges corresponding to the black coordinates "BLACK" are input and set, for example, as "BLACK/Xmin −10, Xmax 10/Ymin 10, Ymax 10" and stored in the range register **23** of RAM **14**. When in such state the range data select key **12***h* ("∇" $12h_2$) is operated, as shown in FIG. **5B**, a blue range setting screen "BLUE/Xmin?, Xmax?/Ymin?, Ymax?" which urges the user to set the X and Y coordinate ranges corresponding to the blue coordinates "BLUE" is displayed on the display **17** (step **S1**→**S2**).

The respective range setting processes and cursor moving process at steps **S3–S7** are then repeated such that the X and

Y coordinate ranges corresponding to the blue coordinates "BLUE" are input and set, for example, as "BLUE/Xmin −5, Xmax 15/Ymin −15, Ymax 5" and stored in the range register **23** of RAM **14**. When in such state the range data selection key **12***h* ("▽" **12***h*$_2$) is operated as shown in FIG. **5**C, a red range setting screen "RED/Xmin?, Xmax?/Ymin?, Ymax?" which urges the user to set the X and Y coordinate ranges corresponding to the red coordinates "RED" is displayed on the display **17** (step S1→S2).

The respective range setting processes and cursor moving process at steps S3–S7 are further repeated such that the X and Y coordinate ranges corresponding to the red coordinates "RED" are input and set, for example, as "RED/Xmin −3, Xmax 17/Ymin −5, Ymax 15" and stored in the range register **23** of RAM **14**. When in such state the range data selection key **12***h* ("▽" key **12***h*$_2$) is operated, as shown in FIG. **5**D, a green range setting screen "GREEN/Xmin?, Xmax?/Ymin?, Ymax?" which urges the player to set X and Y coordinate ranges corresponding to green coordinates "GREEN" is displayed on the display **17**. (step S1→S2).

When the respective range setting processes and cursor moving process at steps S3–S7 are further repeated such that the X and Y coordinate ranges corresponding to the green coordinates "GREEN" are input and set, for example, as "GREEN/Xmin −15, Xmax 5/Ymin 7, Ymax **13**", those data are stored in the range register **23** of RAM **14**.

If the "ENTER" key **12***b* is operated in the state where the four different coordinate ranges are stored in the range register **23** of RAM **14** as the result of the repetition of the steps S1–S7, the four kinds of coordinate ranges "BLACK/ Xmin −10, Xmax 10/Ymin −10 stored in the range register **23**, Ymax 10", "BLUE/Xmin −5, Xmax 15/Ymin −15, Ymax 5" "RED/Xmin −3, Xmax 17/Ymin −5, Ymax 15", and "GREEN/Xmin −15, Xmax 5/Ymin −7, Ymax 13" corresponding to the four different colors are fixed (step S8→S9).

In response to this operation, an input screen for graph expression data "Y1/Y2/Y3/Y4" for graph display corresponding to the four kinds of coordinate ranges "BLACK/ BLUE/RED/GREEN" is displayed on the display **17**, as shown in FIG. **5**E.

When in the graph expression data input process of FIG.3 the cursor keys **12**i ("↑" key **12***i*$_1$, "↓" key **12***i*$_2$, "←" key **12***i*$_3$, "→" key **12***i*$_4$) of the key-in unit **12** are operated, the cursor k is moved on the graph expression data input screen and the position where the graph expression data indicated by the cursor k is input is switched among **Y1**, **Y2**, **Y3** and **Y4** (step A1→A2).

When the numeral keys and function keys **12***a* are operated, for example, to input functional expression "X +2" data in the state where the cursor k is displayed in correspondence to the first graph expression "**Y1**" on the graph expression data input screen, the input first graph expression "**Y1**=X+2" data is stored in the first expression register **19***a* of RAM **14** (step A3→A4).

When the first graph expression "**Y1**=X+2" data stored in the first expression register **19***a* is displayed in the black coordinate range "BLACK/Xmin −10, Xmax 10/Ymin −10, Ymax 10", the user is not required to operate any color designating keys **12***f* since "1" indicative of black display is initially set in the designated color registers **C20** (**20***a*, **20***b*, **20***c*, **20***d*, . . .).

Then, assume that the movement of the inputting position of the graph expression data by the cursor keys **12***i* ("↑" key **12***i*$_1$, "↓" key **12***i*$_2$, "←" key **12***i*$_3$, "→" key **12***i*$_4$) and the inputting process of the functional expression data by the operation of the numeral keys or function keys **12***a* are repeated (steps A1–A5), and for example, the second graph expression "Y_2=2X" data is stored in the second expression register **19***b* of RAM **14**. For example, when in such state the "BLUE" key **12***f*$_1$ of the color designation key **12***f* is operated to display the second graph expression "Y_2=2X" data stored in the second register **19***b* in the blue coordinate range "BLUE/Xmin −5, Xmax 15/Ymin −15, Ymax 5" set and stored in the range register **23**, "2" indicative of blue display is stored and set in the corresponding designated color register **20***b* (step A6→A7).

Thereafter, as shown in FIG. **5**F, the steps A1–A7 are repeated to input third graph expression "Y_3=X−3" data and its designated color "RED" data are input and stored as "Y_3=X−3" and "3" in the third expression register **19***c* and the corresponding designated color register **20***c*, respectively. Fourth graph expression "Y_4=X^2" data and its designated color "GREEN" data are input and stored as "Y_4=X^2" and "4" in the fourth expression register **19***d* and the corresponding designated color register **20***d*, respectively. When the "ENTER" key **12***b* is then operated, the first-fourth graph expression data corresponding to the four different coordinate ranges and their designated color data are fixed (steps A8→A9).

As shown in FIG. **5**G, when the "GRAPH" key **12***d* of the key-in unit **12** is operated in the state where the four kinds of XY coordinate systems "BLACK", "BLUE", "RED" and "GREEN" and corresponding graph expression "Y_1", "Y_2", "Y_3" and "Y_4" data are input, set and stored in the expression registers **19** (**19***a*, **19***b*, **19***c*, **19***d*), the designated color registers **C20** (**20***a*, **20***b*, **20***c*, **20***d*), and the range register **23**, the graph displaying process of FIG. **4** is started up.

In this graph displaying process, first, an XY coordinate system z_1 (FIG. **5**G) scaled as "−10 to 10" for the X coordinates and "−10 to 10" for the Y coordinates respectively, are displayed in black on the display **17** in correspondence to the black coordinate range "BLACK/ Xmin −10, Xmax 10/Ymin −10, Ymax 10" stored in the range data register **23** (step B1).

The black coordinate range data is then substituted into the first graph expression "$Y_{,1}$=X+2" whose data is stored in the expression register **19***a* corresponding to the designated color register **20***a* in which a flag "1" indicative of black display is set to produce first graph data, which is delineated and stored in the graph storage area **21** (step B2).

In response to this operation, the first graph data Y_1 stored in the graph storage area **21** is superimposed and displayed in black on the XY coordinate system displayed in black on the display **17** (step B3).

When the delineation and display of the first graph data Y_1 in the black coordinates is terminated, the X and Y coordinate system z_2 (FIG. **5**G) scaled as "−5 to −15" for the X coordinates and "−15 to 5" for the Y coordinates, respectively, and are displayed in blue on the display **17** in correspondence to the blue coordinate range "BLUE/Xmin −5, Xmax 15/Ymin −15, Ymax 5" stored in the range register **23** (step B4→B5).

The blue coordinate range data is then substituted into the second graph expression "Y_2=2X" whose data is stored in the expression register **19***b* corresponding to the designated color register **20***b* in which a flag "2" indicative of blue display is set to produce second graph data, which is then delineated and stored in the graph storage area **21** (step B6).

In response to this operation, the second graph data Y_2 stored in the graph storage area **21** is superimposed and displayed on the XY coordinate system displayed in blue on the display **17** (step B7).

When the delineation and display of the first and second graph data Y_1 and Y_2 in the black and blue coordinates is terminated, as mentioned above, XY coordinate system z_3 (FIG. 5G) scaled as "−3 to −17" for the X coordinates and "−5 to 15" for the Y coordinates are displayed in red on the display **17** in correspondence to the red coordinate range "RED/Xmin −3, Xmax 17/Ymin 5, Ymax −15" stored in the range register **23**.

The red coordinate range data is then substituted into the third graph expression "Y_3=X−3" whose data is stored in the expression register **19***c* corresponding to the designated color register **20***c* in which a flag "3" indicative of red display is set to produce third graph data, which is then delineated and stored in the graph storage area **21**.

In response to this operation, the third graph data Y_3 stored in the graph storage area **21** is superimposed and displayed in red on the XY coordinate system displayed in red on the display **17** (step B8→B9).

When the delineation and display of the first, second and third graph data Y_1, Y_2 and Y_3 in the black, blue and red coordinates is terminated, as mentioned above XY coordinate system z_4 (FIG. 5G) scaled as "−15 to −5" for the X coordinates and "−7 to 13" for the Y coordinates and are displayed in green on the display **17** in correspondence to the green coordinate range "GREEN/Xmin −15, Xmax 5/Ymin −7, Ymax 13" stored in the range register **23**.

The green coordinate range data is then substituted into the fourth graph expression "Y_4=X^2" whose data is stored in the expression register **19***d* corresponding to the designated color register **20***d* in which a flag "4" indicative of green display is set to produce fourth graph data, which is then delineated and stored in the graph storage area **21**.

In response to this operation, the fourth graph data Y_4 stored in the graph storage area **21** is superimposed and displayed in green on the XY coordinate system displayed in green on the display **17** (step B10).

Thus, as described above, in the graph expression data inputting and displaying process based on the setting of the different coordinate ranges separated in color, four XY coordinate systems corresponding to the four respective different coordinate ranges "BLACK", "BLUE", "RED", "GREEN" and Z_1, Z_2, Z_3, Z_4 are separated and displayed in the corresponding display colors and the graph expression data "Y_1", "Y_2", "Y_3", "Y_4" corresponding to XY coordinate systems for the respective coordinate ranges are separated and displayed in the respective designated colors in correspondence to the set coordinate ranges. Thus, even when the separate graph data corresponding to the four different coordinate ranges are displayed simultaneously, the respective coordinates and the corresponding graph data are displayed so as to be discriminated easily from each other.

FIG. **6** is a flow chart indicative of a range graph display process performed by the computer.

FIGS. **7**A, B and C each show a display operation corresponding to an expression data inputting operation involved in the range graph display process performed by the computer.

For example, as shown in FIG. **7**A, when (1) the numeral keys and function keys **12***a* are operated to input graph expression "GRAPH Y=X^2" data, (2) color-separated display range data "ORANGE [−1, 1]" is input and then (3) the "ENTER" key **12***b* is operated, graph data corresponding to the input graph expression "Y=X^2" data is calculated on the basis of the coordinate ranges set beforehand in correspondence to the display range of the display **17** and delineated and stored in the graph storage area **21** of RAM **14** (step C1).

When it is determined based on the input color-separated display range that the x-coordinate range [−1, 1] and the corresponding color "ORANGE" are designated, only the range of the graph corresponding to the designated X coordinate range [−1, 1] among the graph whose data is stored in the graph storage area **21** is separated and displayed in the designated color (orange) (step C2→C3→C4).

Simultaneously, the graph data outside the designated coordinate range among the graph data stored in the graph storage area **21** is displayed in the basic color (when undesignated, in "BLACK") (step C5, C6).

For example, as shown in FIG. **7**B, when the numeral keys and function keys **12***a* are operated to input graph expression data as "ORANGE GRAPH Y=X^2" by designating its basic color and to input color-separated display range data as "GREEN [−1, 1]" and then the "ENTER" key **12***b* is operated, graph data corresponding to the input graph expression "Y=X^2" data is calculated on the basis of the coordinate ranges set beforehand in correspondence to the display range of the display **17** and delineated and stored in the graph storage area **21** of RAM **14** (C1).

When it is determined on the basis of the input color-separated display range that the X-coordinate range [−1, 1] and the corresponding color "ORANGE" are designated, only the range of the graph corresponding to the designated X coordinate range [−1, 1] among the graph whose data is stored in the graph storage area **21** is separated and displayed in the designated green (step C2→C3→C4).

Simultaneously, the graph portion outside the designated X-coordinate range among the graph whose data is stored in the graph storage area **21** is displayed in the designated orange as the basic color (step C5, C6).

For example, as shown in FIG. **7**C, when the numeral keys and function keys **12***a* are operated to input graph expression "GRAPH Y=X^2" data and to input color-seperated display ranges "ORANGE [−1, 0] data, and GREEN [0, 1]" and then the "ENTER" key **12***b* is operated, graph data corresponding to the input graph expression "Y=X^2" data is calculated on the basis of the coordinate ranges set beforehand in correspondence to the display range of the display **17** and delineated and stored in the graph storage area **21** of RAM **14** (step C1).

When it is determined on the basis of the input color-separated display range that the x-coordinate range [−1, 0], [0, 1] and the corresponding color "ORANGE", "GREEN" are designated, the range of the graph data corresponding to the designated x-coordinate ranges [−1, 0] and [0, 1] among the graph data stored in the graph data storage area **21** are separated and displayed in the designated orange and green, respectively (step C2→C3→C4).

Simultaneously, the graph portion outside the designated coordinate ranges among the graph whose data is stored in the graph storage area **21** is displayed in the basic color (when undesignated, in black)(step C5, C6).

When it is determined that there is no designated range data corresponding to the X coordinates at step graph data stored in the graph storage area **21** is directly displayed in the basic color (when undesignated, in black) (step C2→C7, C6).

If it is determined at step C3 that there is no designated color data even when it is determined at step C2 that there is designated X-coordinate range data, only the range of graph corresponding to the designated X-coordinate range among graph data stored in the graph storage area **21** is displayed separately in red and graph portion outside the designated coordinate range is displayed in the basic color (when undesignated, in black) (step C2→C3→C8, C5, C6).

Thus, when in the range graph displaying process the graph expression data and the range data corresponding to the X coordinates are input, only a portion of the graph for the graph expression and corresponding to the input range data is displayed in a color different from that for the remaining portion of the graph for the graph expression and the remaining graph data is displayed in the basic color. Thus, the whole shape of the graph for the graph expression is gripped in a clearly color-separated manner from the shape of the designated range of the graph.

While in the embodiment the range for the X coordinates has been designated by inputting the corresponding range data, the range may be designated by Y coordinates, of course.

FIG. **8** is a flow chart indicative of a coordinate data boxing process performed by the computer;

FIGS. **9A–9E** each shows display operations corresponding to key operations involved in the coordinate data boxing process performed by the computer.

As shown in FIG. **9A**, for example, in the graph expression data inputting process of FIG. **3**, two-graph expressions "$Y_1=X^2$", "$Y_2=X-1$" data and the corresponding display color "GREEN", "BLUE" data are input, designated, respectively, and displayed and stored in the expression registers **19***a*, **19***b* and the designated color registers **20***a*, **20***b*, respectively. As shown in FIG. **9**B, when the "GRAPH" key **12***d* is then operated, the graph display process of FIG. **4** is performed in which graph data corresponding to the first graph expression "$Y_1=X^2$", data stored in the first expression register **19***a* is displayed in green in correspondence to the display color "GREEN" designated in the designated color register **20***a*, and graph data corresponding to the second graph expression "$Y_2=X-1$" stored in the second expression register **19***b* is displayed in blue in correspondence to the display color "BLUE" designated in the designated color register **20***b*.

As shown in FIG. **9**C, when the "BOX" key **12***c* of the key-in unit **12** is operated in the state where the desired graph data is displayed in color on the display **17**, the boxing process of FIG. **8** is started up to thereby display the cursor k at the center of the graph display screen (step D1).

When the cursor keys **12***i* ("↑" key 12_i, "→" key $12i_4$) are sequentially operated, the cursor k on the screen is moved rightward and upward (step D2→D3).

At this time, since the cursor setting flag register n in RAM **14** is set initially at "0", "NO" is determined at step D4.

As shown in FIG. **9**D, when the "ENTER" key **12***b* is operated in the state where the cursor k on the graph display screen is moved to a first cursor position P1, it is determined that "0" is set in the cursor setting flag register n, X/Y coordinate data corresponding to the first cursor position P1 are stored in the work area **22**, and "1" is then set in the cursor setting flag register n (step D5→D6→D7, D8).

When the cursor keys **12***i* ("→" key $12i_4$, "1" key $12i_2$) are then operated sequentially, the cursor k on the screen is moved from the first cursor position P1 rightward and downward (step D2→D3).

At this time, since the cursor setting flag register n in RAM **14** is set at "1" when the first cursor position P1 was set, "YES" is determined at step D4 and a box corresponding to the first cursor position P1 and the current position of the cursor k is displayed (step D4→D9).

As shown in FIG. **9**E, when the "ENTER" key **12***b* is operated in the state where the cursor k on the graph display screen is moved to a second cursor position P2 and a desired range on the graph display screen is enclosed in a box, X/Y coordinate data corresponding to the second cursor position P2 are stored in the work area **22** because it is determined that "1" is set in the cursor setting flag register n (step D5→D6→D10).

In response to this operation, graph data in the X/Y coordinate range enclosed in the box is retrieved on the basis of the graph data corresponding to the first and second graph expressions "$Y_1=X^2$", and "$Y_2=X-1$" data stored in the graph storage area **21** and the respective X/Y coordinate data corresponding to the first and second cursor positions **P1**, **P2** stored in the work area **22**, and the retrieved graph data in the box is displayed separately in red (steps **D11**, **D12**).

Simultaneously, the box shape displayed when the cursor was moved from the first cursor position P1 to the second cursor position P2 is erased (step D13).

Thus, in the boxing process, the graph data in the range enclosed in the box as the cursor was moved on the display screen for the desired graph data is displayed separately in a different color.

Thus, according to the present computer as the embodiment, in the whole graph coordinate range setting process started up by the "RANGE" key **12***g* of the key-in unit **12**, four-different X and Y coordinate range data are set in the range register **23** of RAM **14** in correspondence to the display colors "BLACK", "BLUE", "RED" and "GREEN" and the graph expression data displayed in the respective coordinate ranges are input in the corresponding display colors and stored in the expression register **19** of RAM **14**. When the "GRAPH" key **12***d* is operated to designate graph display in such state, the respective X/Y coordinates in the four different coordinate ranges set in the range register **23** are displayed as "black coordinates", "blue coordinates", "red coordinates" and "green coordinates" in corresponding different colors, and graph expression data placed in corresponding relationship to respective color designating data which each designate the same color as a respective one of the XY coordinate systems are produced, the corresponding expression graphs are delineated and displayed in the respective colors designated by the color designated data. Thus, even when separate graph data based on different coordinate ranges are displayed simultaneously, the respective graph data can be discriminated easily from each other.

According to the present computer as the embodiment, graph expression data is input, the coordinate range corresponding to X or Y coordinates is designated in color and set. When graph delineation is designated, graph data for the graph expression is produced, only graph data for the set coordinate range is separately displayed in a designated color and graph data outside the set range is displayed in the basic color (when undesignated, in black). Thus, the whole shape of the graph and the graph data and the shape of the graph portion in the set range are displayed in an easily discriminable manner.

What is claimed is:

1. A graph displaying device comprising:

functional expression data inputting means for inputting functional expression data representing a functional expression including a plurality of variables;

range setting means for setting a range of at least one of the plurality of variables included in the functional expression using a numerical input;

storage means for storing the set range and the functional expression data in corresponding relationship;

graph producing means for producing a graph of the functional expression represented by the functional expression data stored in the storage means;

graph displaying means for displaying the graph produced by the graph producing means; and

range graph displaying means for causing a portion of the displayed graph in the corresponding set range stored in the storage means to be displayed in a color which is different from that of a remainder of the graph.

2. The graph displaying device according to claim 1, further comprising display color designating means for designating the different color in which the portion of the displayed graph is to be displayed.

3. The graph displaying device according to claim 1, further comprising display color setting means for setting color data with respect to the input functional expression data, and wherein the graph displaying means comprises means for displaying the graph in color in accordance with the set color data.

4. The graph displaying device according to claim 1 wherein said range setting means comprises means for setting a plurality of ranges with respect to at least one of the plurality of variables included in the functional expression represented by the functional expression data, and said range graph displaying means comprises means for causing a plurality of portions of the displayed graph in the plurality of set ranges to be displayed in a corresponding plurality of different colors which are different from that of a remainder of the graph.

5. The graph displaying device according to claim 4, further comprising display color designating means for designating the plurality of different colors in which the plurality of portions of the displayed graph are to be displayed.

6. A graph displaying device comprising:

functional expression data inputting means for inputting functional expression data representing a plurality of functional expressions;

functional expression color data inputting means for inputting functional expression color data representing a plurality of different colors corresponding to the plurality of functional expressions;

functional expression and color data storing means for storing the functional expression data and the functional expression color data in corresponding relationship;

coordinate axis range data inputting means for inputting range data representing a plurality of ranges of X and Y coordinate axes;

coordinate axis range color data inputting means for inputting range color data representing a plurality of different colors corresponding to the plurality of ranges of X and Y coordinate axes;

coordinate axis range and color storage means for storing the range data and the range color data in corresponding relationship;

coordinate axis display means for displaying a plurality of coordinate systems of X and Y coordinate axes corresponding to the range data stored in the coordinate axis range and color data storage means in the corresponding plurality of different colors represented by the range color data stored in the coordinate axis range and color data storage means;

graph producing means for producing, on the displayed plurality of coordinate systems of X and Y coordinate axes, a plurality of graphs of the plurality of functional expressions represented by the functional expression data stored in the functional expression and color data storing means; and

graph displaying means for causing the displayed plurality of graphs to be displayed in the corresponding plurality of different colors represented by the functional expression color data stored in the functional expression and color data storing means in a manner such that respective graphs of a given color are displayed on respective coordinate axes of the same color.

7. A recording medium having recorded thereon a computer readable program for enabling a computer to operate as:

functional expression data inputting means for inputting functional expression data representing a functional expression including a plurality of variables;

range setting means for setting a range of at least one of the plurality of variables included in the functional expression using a numerical input;

storage means for storing the set range and the functional expression data in corresponding relationship;

graph producing means for producing a graph of the functional expression represented by the functional expression data stored in the storage means;

graph displaying means for displaying the graph produced by the graph producing means; and

range graph displaying means for causing a portion of the displayed graph in the corresponding set range stored in the storage means to be displayed in a color which is different from that of a remainder of the graph.

8. A recording medium having recorded thereon a computer readable program for enabling a computer to operate as:

functional expression data inputting means for inputting functional expression data representing a plurality of functional expressions;

functional expression color data inputting means for inputting functional expression color data representing a plurality of different colors corresponding to the plurality of functional expressions;

functional expression and color data storing means for storing the functional expression data and the functional expression color data in corresponding relationship;

coordinate axis range data inputting means for inputting range data representing a plurality of ranges of X and Y coordinate axes;

coordinate axis range color data inputting means for inputting range color data representing a plurality of different colors corresponding to the plurality of ranges of X and Y coordinate axes;

coordinate axis range and color storage means for storing the range data and the range color data in corresponding relationship;

coordinate axis display means for displaying a plurality of coordinate systems of X and Y coordinate axes corresponding to the range data stored in the coordinate axis range and color data storage means in the correspond

ing plurality of different colors represented by the range color data stored in the coordinate axis range and color data storage means;

graph producing means for producing, on the displayed plurality of coordinate systems of X and Y coordinate axes, a plurality of graphs of the plurality of functional expressions represented by the functional expression data stored in the functional expression and color data storing means; and

graph displaying means for causing the displayed plurality of graphs to be displayed in the corresponding plurality of different colors represented by the functional expression color data stored in the functional expression and color data storing means in a manner such that respective graphs of a given color are displayed on respective coordinate axes of the same color.

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